2 Ties

tie

A *tie* is a member in tension, typical examples being a car tow rope or hoist cable. A rope or cable is flexible — it bends and twists easily. This is not detrimental to its operation as a tension member because it pulls straight automatically. The flexibility may be a great advantage as the rope or cable can be wound on to a drum or coiled up for storage. Alternatively a tie may be rigid and in some cases is not obviously different from a strut. In fact, one member may be called upon to do both jobs at different times. The largest ties that I know of are the main cables of suspension bridges.

You have already done some calculations on tension members in the stress analysis unit (Unit 10). The average tensile stress is $\sigma = F/A$, and this can be compared with the chosen limit stress of the material, σ_Y or σ_F, to find the stress safety factor. Alternatively, the limit stress times the area gives the limit load which, divided by the load, gives the load safety factor. For a tension member the two safety factors are equal, but this is not true for struts because of the stability problem. Even so, tension members usually have quite large safety factors, because of the stress-raising effects of end connections, bending around pulleys, handling damage, sensitivity to cracks, and so on.

Under moderate load a tie extends approximately according to $F/A = Ee/L$, as you saw in Unit 10. In a few special cases this stretching may be excessive even if the strength safety factor is adequate. This would of course be a stiffness failure, in which case the cross-sectional area could be increased or a stiffer material used. Here is one possible procedure for tie design checking:

Tie design check procedure

1. Calculate average working stress $\sigma = F/A$
2. $\mathrm{SSF} = \sigma_F/\sigma$ or σ_Y/σ
3. Is the SSF acceptable?
4. $e = FL/EA$
5. Is extension e acceptable?

However, many problems will require you to manipulate these basic equations in whatever is the most appropriate way. Acceptable safety factors and extensions depend upon individual cases and I cannot give you any useful general rules here.

SAQ 3

A 100 m long vertical steel cable ($\sigma_Y = 280\ \mathrm{MN\,m^{-2}}$, $E = 210\ \mathrm{GN\,m^{-2}}$) contains 100 strands, each of diameter 1.0 mm. It is required to carry a tension of 4 kN with a stress safety factor of at least 4, and without stretching more than 50 mm. Is it acceptable? (Neglect the cable weight.)

SAQ 4

A surveyor's steel tape ($E = 200\ \mathrm{GN\,m^{-2}}$, $\sigma_Y = 300\ \mathrm{MN\,m^{-2}}$) is 50 m long and is expected to be used at tensions up to 100 N.

(a) To prevent inaccuracies of measurement, the stretching due to this force must be kept below 2.5 mm. Find the minimum cross-sectional area for suitable stiffness.

(b) Obviously if the tape ever yields it will be permanently inaccurate. If the 'minimum-stiffness' cross-sectional area is used, what is the safety factor for yielding?

(c) Can you suggest how the tape should be used to minimize stretching errors?
